U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM

Scientific Name:

Linum arenicola

Common Name:

Sand flax

Lead region:

Region 4 (Southeast Region)

Information current as of:

03/27/2013

Status/Action

___ Funding provided for a proposed rule. Assessment not updated.

___ Species Assessment - determined species did not meet the definition of the endangered or threatened under the Act and, therefore, was not elevated to the Candidate status.

___ New Candidate

_X_ Continuing Candidate

___ Candidate Removal

> ___ Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status
>
> ___ Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species
>
> ___ Range is no longer a U.S. territory
>
> ___ Insufficient information exists on biological vulnerability and threats to support listing
>
> ___ Taxon mistakenly included in past notice of review
>
> ___ Taxon does not meet the definition of "species"
>
> ___ Taxon believed to be extinct
>
> ___ Conservation efforts have removed or reduced threats

___ More abundant than believed, diminished threats, or threats eliminated.

Petition Information

___ Non-Petitioned

_X_ Petitioned - Date petition received: 05/11/2004

90-Day Positive:05/11/2005

12 Month Positive:05/11/2005

Did the Petition request a reclassification? **No**

For Petitioned Candidate species:

Is the listing warranted(if yes, see summary threats below) **Yes**

To Date, has publication of the proposal to list been precluded by other higher priority listing? **Yes**

Explanation of why precluded:

Higher priority listing actions, including court-approved settlements, court-ordered and statutory deadlines for petition findings and listing determinations, emergency listing determinations, and responses to litigation, continue to preclude the proposed and final listing rules for this species. We continue to monitor populations and will change its status or implement an emergency listing if necessary. The Progress on Revising the Lists section of the current CNOR (http://endangered.fws.gov/) provides information on listing actions taken during the last 12 months.

Historical States/Territories/Countries of Occurrence:

- **States/US Territories**: Florida
- **US Counties**: Monroe, FL
- **Countries**:Country information not available

Current States/Counties/Territories/Countries of Occurrence:

- **States/US Territories**: Florida
- **US Counties**: Miami-Dade, FL, Monroe, FL
- **Countries**:Country information not available

Land Ownership:

Varied, see Tables 1 and 2. There are 10 extant occurrences, all on public land (Bradley and van der Heiden 2013, pp. 6,19). There are also 3 historical occurrences, meaning they were not found during the most recent survey but could re-appear. The largest population in Monroe County is located on Big Pine Key within National Key Deer Refuge (NKDR) and surrounding lands, where there are approximately 1,181 acres (ac) (478 hectares (ha)) of publicly owned pine rockland (Gann et al. 2002, p. 806; Bradley 2006, p. 4; Hodges and Bradley 2006, pp. 37-38). The largest population in Miami-Dade County is located on property owned by the Miami-Dade County Homeless Trust. The U.S. Special Operations Command South (SOCSOUTH) seeks

to enter into a 50-year agreement with Miami-Dade County to lease this 90-ac (36.4-ha) area so that permanent headquarters can be built on approximately 28 ac (11.3 ha) (Department of Defense 2009, p. 1).

Lead Region Contact:

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Biological Information

Species Description:

Sand flax is a wiry, yellow-flowered herb (Bradley and Gann 1999, p. 61). Bradley and Gann (1999, p. 61) stated that sand flax is a glabrous perennial herb; stems 1-several from the base, wiry, 35-53 centimeters (cm) (14-21 inches (in)) tall; leaves mostly alternate, linear, 7-10 millimeters (mm) (0.3-0.4 in) long, 0.6-1 mm (0.02-0.04 in) wide, entire or with scattered marginal glands; stipules glandular, reddish; inflorescence a cyme of a few slender, spreading or ascending branches; pedicels 2 mm (0.08 in) long or less; sepals lanceolate to ovate with a prominent midrib, 2.4-3.2 mm (0.09-0.13 in) long; petals yellow, obovate, 4.5-5.5 mm (0.18-0.22 in) long; fruit 2.1-2.5 mm (0.08-0.1 in) long, 2-2.3 mm (0.08-0.09 in) diameter, pyriform, dehiscing into ten segments; seeds ovate, 1.2-1.4 mm (0.05-0.06 in) long, 0.7-0.8 mm (0.027-0.031 in) wide. (Adapted from Rogers 1963).

The reproductive ecology and biology of this taxon has not been studied (Bradley and Gann 1999, p. 62), and few studies have been conducted on its ecology (Bradley 2006, p. 5).

Taxonomy:

Hodges and Bradley (2006, p. 37) stated that This species was first described by Small in 1907 as *Cathartolinum arenicola* for plants he collected in Miami-Dade County in 1904. This treatment was consistently followed by Small (1913a, 1913b, 1933). In 1931, Winkler included Cathartolinum within the genus *Linum*, renaming the plants *Linum arenicola*. Others have followed this treatment, including Rogers (1963), Long and Lakela (1971), Robertson (1971), Wunderlin (1998), and Wunderlin & Hansen (2003). Cathartolinum arenicola Small is a synonym (Bradley and Gann 1999, p. 61; Wunderlin and Hansen 2004, p. 5; Hodges and Bradley 2006, p. 37).

The Integrated Taxonomic Information System (2011, p. 1) uses the name Linum arenicola and indicates that this species taxonomic standing is accepted. NatureServe (2010, p. 1) uses the name *L. arenicola*. The online Atlas of Florida Vascular Plants (Wunderlin and Hansen 2008, p. 1) uses the name *L. arenicola*. The Florida Department of Agriculture and Consumer Services (FDACS) uses the name *L. arenicola*. There is consensus that *L. arenicola* is a distinct taxon. We have carefully reviewed the available taxonomic information to reach the conclusion that the species is a valid taxon.

Habitat/Life History:

Sand flax is found in pine rockland, disturbed pine rockland, marl prairie, roadsides on rocky soils, and disturbed areas (Bradley and Gann 1999, p. 61; Hodges and Bradley 2006, p. 37). Bradley and Gann (1999, p. 61) stated, It grows on oolitic limestone formations. The pine rockland and marl prairie where this species occurs requires periodic wildfires in order to maintain an open, shrub free subcanopy and reduce litter levels. This taxon is currently rare in relatively undisturbed natural areas, with the exception of plants on Big Pine

Key and the grounds of an office building on Old Cutler Road. Several occurrences are in scarified pine rockland fragments that are dominated by native pine rockland species, but have little or no canopy or subcanopy. One population in Miami-Dade County occurs entirely on a levee composed of crushed oolitic limestone in the middle of a sawgrass marsh.

More recently, Hodges and Bradley (2006, p. 41) found that in the Keys, sand flax seems to only rarely occur within intact pine rockland; more frequently it occurs in disturbed areas adjacent to intact pine rockland. Its persistence on roadsides is not fully understood, but it is possible that this species has evolved to occur in this habitat as fire regimes and natural areas were altered and destroyed over the last several hundred years (Hodges and Bradley 2006, p. 41).

Historical Range/Distribution:

Sand flax historically was distributed in Monroe County in the lower Keys and in central and southern Miami-Dade County (Bradley and Gann 1999, p. 61). In Miami-Dade County, the plant was widespread from the Coconut Grove area to the southern part of the county, close to what is now the main entrance to Everglades National Park and Turkey Point (Bradley and Gann 1999, p. 61). In Monroe County, the plant was recorded from Big Pine, Ramrod, Sugarloaf, Park, Boca Chica, and Middle Torch Keys (Bradley and Gann 1999, p. 61). Based upon Bradley and Gann (1999, p. 65), Hodges and Bradley (2006, pp. 39-40), data from The Institute for Regional Conservation (IRC) (K. Bradley, IRC, pers. comm. 2007), and Bradley and van der Heiden (2013, pp. 6-12,19), sand flax has been extirpated from the sites in Table 1.

Table 1. Extirpated occurrences of sand flax.

Current Range Distribution:

Sand flax is currently known from four occurrences in the Keys and six occurrences in Miami-Dade County (Bradley 2006, p. 5; K. Bradley, pers. comm. 2007, 2011; J. Maschinski, Fairchild Tropical Botanic Garden [FTBG], pers. comm. 2007, 2011; J. Possley, FTBG, pers. comm. 2011; Bradley and van der Heiden 2013, pp. 6, 19). Based upon Bradley and Gann (1999, p. 65), Hodges and Bradley (2006, pp. 37-39), Bradley (2009, pp. 1-13), data from IRC (K. Bradley, pers. comm. 2007; Gann *et al*. 2001-2010, p. 1), data from FTBG (Maschinski *et al*. 2002, Appendix B1, p. 6; J. Maschinski, pers. comm. 2007; J. Possley, pers. comm. 2011; J. Maschinski, pers. comm. 2011), Bradley and Saha (2009, p. 10), and Bradley and van der Heiden

(2013, pp. 7-12, 19), sand flax is extant at the sites in Table 2. On Big Pine Key, sand flax occurs at the Terrestris Preserve, which is owned by The Nature Conservancy (TNC); this occurrence is included within the Big Pine Key site in Table 2.

Table 2. Extant occurrences of sand flax.

Hodges and Bradley (2006, pp. 1-79) conducted population surveys for sand flax in the Keys on Big Pine Key and other keys with potential habitat. The survey included extant occurrences, historic sites, and exploratory surveys of potential habitat. This project provided the first comprehensive survey of distribution and abundance for the area. Negative survey results (i.e., location surveyed, but sand flax absent) included: Boca Chica Key (southern edge), No Name Key (roadside edges and NKDR), Ramrod Key (Dan Austin Site), roadsides from Little Torch Key to Lower Sugarloaf Key, and Upper Sugarloaf Key (NKDR) (Hodges and Bradley 2006, p. 48).

In 2009, an assessment of rare plants and pine rockland habitat was conducted for a proposed U.S. Army SOCSOUTH headquarters at the site adjacent to the Homestead Air Reserve Base (HARB)(Bradley 2009, pp. 1-13). During a survey of the 90-ac (36.4-ha) tract, Smalls milkpea (Galactia smallii) (federally endangered) and sand flax were found in 27 different locations covering 13.2 ac (5.3 ha) in disturbed pine rocklands (Bradley 2009, pp. 3, 7). In 2013, surveys indicated that sand flax was persisting at SOCSOUTH and was also found on Homestead Air Reserve Base and the decommissioned, County-owned Homestead Air Force Base (Bradley and van der Heiden 2013, pp. 6, 9-12, 19).

Population Estimates/Status:

See Table 2. In Miami-Dade County, Kernan and Bradley (1996, pp. 5, 24) reported six mainland occurrences for sand flax. They estimated that approximately 1,000 plants occurred in Miami-Dade County, with about 600 at HARB (Kernan and Bradley 1996, pp. 5-6, 19). In 2008, Bradley (pers. comm. 2008) estimated that hundreds of plants, possibly thousands, remained at this site, now owned by the Miami-Dade County Homeless Trust. In 2009, Bradley (2009, p. 3) estimated that approximately 74,000 sand flax plants occur on the site, with densities ranging as high as 4.5 plants per 10.8 feet2 (per 1.0 m2). This is the largest known population in Miami-Dade, but a portion of it is threatened by development; SOCSOUTH seeks to locate permanent headquarters at this site (Department of Defense 2009, p. 1). Project plans include avoidance of the majority of the population with accompanying protection and management of approximately

60,000 individuals (Service 2011, p. 13). However, this project will need to be carefully monitored because impacts would affect the largest known occurrence of the species. In 2013, Bradley and van der Heiden (2013, p. 6) estimated the total sand flax population on the six sites in Miami-Dade County to be 107,060 plants, with approximately 100,000 plants associated with the Homestead Air Reserve Base and decommissioned properties adjacent to the base.

An occurrence called Old Cutler (now a gas station) contained 26 percent of the known individuals in Miami-Dade County, prior to being cleared (Kernan and Bradley 1996, pp. 5-6; Bradley and Gann 1999, p. 62). Bradley and Gann (1999, pp. 61-63) identified the following threats: development, exotic plants, hydrologic modifications, changes in fire regime, mechanical disturbance, and herbicide use. They suggested that some small occurrences in Miami-Dade County will likely disappear due to disturbances and indicated that two occurrences had been lost in the last 4 years (Bradley and Gann 1999, p. 62). Similarly, Kernan and Bradley (1996, p. 7) stated that no population of sand flax is secure in Miami-Dade County. In 2013, surveys indicated that five occurrences have been extirpated (Bradley and van der Heiden 2013, p. 19). Jennifer Possley (FTBG) and Keith Bradley (IRC) found a population at Luis B. Martinez Army Reserve Station in 2004 and estimated the population size to be 30-50 plants (J. Maschinski, pers. comm. 2007). In 2011, no plants were observed on this site (Bradley and van der Heiden 2013, pp. 10-11, 19). In 1996, the species mainland range was from just north of SW 184 Street south to SW 288 Street and west to SW 264 Street and 177 Avenue; a distance of approximately 11.5 miles (18.5 kilometers [km]) northeast to southwest (Kernan and Bradley 1996, p. 5). Historically, the greatest distance between any two mainland populations was approximately 29.1 miles (47 km). The geographic range on the mainland has contracted approximately 61 percent (Kernan and Bradley 1996, p. 5). In the Keys, the range was historically as far as Boca Chica Key, where now it extends only to Lower Sugarloaf Key.

More detailed information is available for the Keys. Neither Dickson (1955, pp. 16-61) nor Alexander and Dickson (1972, pp. 85-95) reported the species in their studies. Carlson *et al*. (1993, p. 922) recorded it at a frequency of 1.3 percent in study plots (0.5 meter2 [m]). Ross and Ruiz (1996, p. 5) found sand flax in only 16 plots in five Big Pine Key transects, none of which were west of Key Deer Boulevard (i.e., in 16 of 145 study plots [5 m radius] [11.0 percent]). According to their analysis, sites most likely to support sand flax had a high relative representation of graminoids in the understory, abundant pine regeneration, and high cover of exposed rock (Ross and Ruiz 1996, pp. 5-6).

In the first comprehensive study of distribution and abundance in the Keys, Hodges and Bradley (2006, p. 40) estimated that there were between 101 and 1,000 plants in the Keys outside of Big Pine Key (Table 2). In a follow-up study, examining the distribution and population size on Big Pine Key, sand flax was found to be extremely rare, located at only five sample locations throughout the island and at three places not associated with sample locations (Bradley 2006, pp. 19-21). Bradley (2006, p. 11) found a total of 33 plants, mostly in the interior of the island away from the coast. In the northern pinelands, it was found in 6 of 427 plots (1.4 percent) at a density of 0.07 ± 0.09 plants / plot (Bradley 2006, p. 19). In the southern pinelands, it was found in 1 of 114 plots (0.9 percent) at a density of .009 ± 0.91 plants / plot (Bradley 2006, p. 19). The difference in density was significant (U = 32,978.5, P = 0.033). Since sand flax was found at such low densities in so few plots, the mean density had an extremely broad range; 95 percent confidence intervals showed a range from -3,353 to 56,404 individuals (Bradley 2006, p. 35). In general, sand flax was found to be extremely rare, occurring in only a few study locations prior to Hurricane Wilma (Bradley 2006, p. 19). The species was not found in any study location during surveys conducted 8-9 weeks post-hurricane (Bradley 2006, pp. 19, 36). In 2007, Bradley and Saha (2009, p. 10) found sand flax in northern plots, but did not find it in any of the southern plots. Additional surveys have not been conducted, so it is not possible to determine if sand flax has recovered.

The pine rocklands of Big Pine Key and other islands were re-inventoried in 2007 to assess hurricane impacts on this and other rare plants (Bradley and Saha 2009, pp. 1-31). Sand flax was recorded in 4 of 228 northern plots (2 percent frequency), but was not found in any of the southern plots (Bradley and Saha 2009, p. 10). Based upon this study, there were an estimated 2,676 plants in pine rocklands on Big Pine Key (Bradley and

Saha 2009, p. 10). Long-term ecological changes on Big Pine Key associated with fire suppression, land clearing, sea level rise, changes in hydrology, fluctuations in Key deer (*Odocoileus virginianus clavium*) densities, and invasion of exotic plants may have impacted the population sizes of this species (Bradley 2006, p. 2; Bradley and Saha 2009, p. 2). These same factors are likely to impact the species in the future.

Updated monitoring information from TNC indicates that no sand flax was found on transects in any of the management units at the Terrestris Preserve in the Keys in 2006 (Slapcinsky and Gordon 2007, pp. 4-5; D. Gordon, TNC, pers. comm. 2008). Slapcinsky and Gordon (2007, pp. 4-5) generally found density of sand flax declined to zero in all three burn units (burns were conducted from 1994 to 2003) in 2006. This uniform loss is of concern and can be attributed to the damaging effects of Hurricane Wilma in 2005 (Slapcinsky and Gordon 2007, pp. 1, 6-7; D. Gordon pers. comm. 2008).

The species was not found during a 2-year project intended to survey and map exotic and rare plants along Florida Department of Transportation (FDOT) right-of-ways within Miami-Dade and Monroe Counties (Gordon et al. 2007, pp. 1, 39). However, a new occurrence has been confirmed recently in Miami-Dade County on a tract of land enrolled in the Environmentally Endangered Lands program, which is an addition to Camp Owaissa Bauer Pineland (J. Possley, pers. comm. 2011).

The global status of sand flax is considered to be G1G2, imperiled to critically imperiled (NatureServe 2010, p. 1). Florida Natural Areas Inventory [FNAI] (2011, p. 6) ranks it as G1G2, critically imperiled globally or imperiled globally. IRC considers its status as imperiled (Gann et al. 2001-2010, p. 1). Sand flax is listed as endangered by the State.

Threats

A. The present or threatened destruction, modification, or curtailment of its habitat or range:

Residential and commercial development has drastically reduced the habitat for sand flax in pine rocklands of south Florida and the Keys. Pine rocklands in Miami-Dade and Monroe Counties have lost nearly 90 percent of their area due to agricultural and residential development (OBrien 1998, p. 208). Development has reduced the coverage of pine rocklands from 130,358 ac (52,754 ha) to 15,256 ac (6,174 ha) (OBrien 1998, pp. 208, 212). Most of the ecosystems in the Keys have been impacted by humans through widespread clearing of rockland hammocks in the 19th century for farming or building of homes and businesses (Hodges and Bradley 2006, p. 6). Disruption of the historic fire regime in pine rocklands has probably caused a decrease in the plant diversity on islands with that habitat (Hodges and Bradley 2006, p. 6).

Habitat loss continues to occur in this species range and most remaining suitable habitat has been negatively altered by human activity. For example, fragmented habitat is currently at risk of being cleared for such uses as parking. Outside of Everglades National Park, only about 1 percent of the Miami Rock Ridge pinelands have escaped clearing and much of what is left is in small remnant blocks isolated from other natural areas (Herndon 1998, p. 1). Disturbed pine rocklands supporting the largest population of sand flax is currently at-risk. The U.S. Special Operations Command South (SOCSOUTH) seeks to enter into a 50-year agreement with Miami-Dade County to lease the 90-ac (36.4-ha) area adjacent to HARB so that permanent headquarters can be built on approximately 28 ac (11.3 ha) (Department of Defense 2009, p. 1). Project plans include avoidance of the majority of the population with accompanying protection and management of approximately 60,000 individuals (Service 2011, p. 13). However, this project will need to be carefully monitored because impacts would affect the largest known occurrence of the species. A detailed assessment of plants and habitat with site-specific management recommendations has been completed (Bradley 2009, pp. 1-13) (see Recommended Conservation Measures) and a Management Plan is being drafted (Reaves 2010, pp. 1-13).

Some opportunities exist to conserve this plant on private land in Miami-Dade County, but there is little

opportunity to acquire more conservation lands. Conservation of privately-owned pine rocklands in Miami-Dade County is largely a matter of County government cooperation with private landowners and the County offers incentives for landowners to maintain their natural forest communities (NFCs).

On Big Pine Key, Bradley and Saha (2009, p. 4) determined that pine rockland now covers approximately 1,438 ac (582 ha) of the island, 55.5 percent of the historical estimate determined by Folk (1991 pp. 35-39). Bradley and Saha (2009, p. 4) estimated that there are 1,001 ac (405 ha) in the northern pinelands and 437 ac (177 ha) in the southern pinelands. Most of the pine rockland that remains on Big Pine Key (1,181 ac [478 ha] or 82 percent) is preserved within the NKDR and properties owned by TNC, the State of Florida, and Monroe County; however, the northern and southern pine rockland areas differ in amount of protection and habitat quality (see Factor E).

All available vacant land in the Keys is projected to be consumed by development by 2060, including lands not necessarily accessible by automobile (Zwick and Carr 2006, pp. 14-15). Similarly, in Miami-Dade County, significant conversion of lands in the southern portion of the County is projected between now and 2060 (Zwick and Carr 2006, p. 14). Overall, the population in Miami-Dade County is expected to increase from more than 2.4 million people to more than 4.0 million (Zwick and Carr 2006, p. 20).

Climatic changes, including sea level rise, are major threats to south Florida, including this species and its habitat. The Intergovernmental Panel on Climate Change (IPCC) reported that the warming of the worlds climate system is unequivocal based on documented increases in global average air and ocean temperatures, unprecedented melting of snow and ice, and rising average sea level (IPCC 2007, p. 2; 2008, p. 15). Sea-level rise is the largest climate-driven challenge to low-lying coastal areas and refuges in the sub-tropical ecoregion of southern Florida (U.S. Climate Change Science Program [CCSP] 2008, pp. 5-31, 5-32). The long-term record at Key West shows that sea level rose on average 0.088 inches (0.224 cm) annually between 1913 and 2006 (National Oceanographic and Atmospheric Administration [NOAA] 2008, p. 1). This equates to approximately 8.76 inches (22.3 cm) over the last 100 years (NOAA 2008, p. 1).

IPCC (2008, p. 28) emphasized it is very likely that the average rate of sea-level rise during the 21st century will exceed that from 1961 to 2003 (i.e., 0.071 inches [0.18 cm] per year), although it was projected to have substantial geographical variability. Partial loss of the Greenland and/or Antarctic ice sheets could result in many feet (several meters) of sea-level rise, major changes in coastlines, and inundation of low-lying areas (IPCC 2008, pp. 28-29). Low-lying islands and river deltas will incur the largest impacts (IPCC 2008, pp. 28-29). Because dynamic ice flow processes in ice sheets are poorly understood, timeframes are not known; however, modeling indicates that more rapid sea-level rise on century timescales cannot be excluded (IPCC 2008, p. 29). According to CCSP (2008, p. 5-31), much of low-lying, coastal south Florida will be underwater or inundated with salt water in the coming century.

IPCC (2008, pp. 3, 103) concluded that climate change is likely to increase the occurrence of saltwater intrusion into coastal aquifers as sea level rises and that sea-level rise is projected to extend areas of salinisation of groundwater and estuaries, resulting in a decrease of freshwater availability for humans and ecosystems in coastal areas. Since the 1930s to 1950s, increased salinity of coastal waters contributed to the decline of cabbage palm forests in southwest Florida (Williams *et al*. 1999, pp. 2056-2059), expansion of mangroves into adjacent marshes in the Everglades (Ross *et al*. 2000, pp. 9, 12-13), and loss of pine rockland in the Keys (Ross *et al*. 1994, pp. 144, 151-155). Hydrology has a strong influence on plant distribution in these and other coastal areas (IPCC 2008, p. 57). Such communities typically grade from salt to brackish to freshwater species. In the Keys, not only are elevation differences between such communities very slight (Ross *et al*. 1994, p. 146), but the horizontal distances are small as well. Human developments will also likely be significant factors influencing whether natural communities can move and persist (IPCC 2008, p. 57; CCSP 2008, p. 7-6). Hodges and Bradley (2005, p. 6) stated that the trend of upland habitat reduction will undoubtedly impact sand flax in the Keys. Similarly, Clough (2008, p. 23) concluded that a significant proportion of upland habitat will be lost on Big Pine Key by 2100.

TNC (2010, p. 1) used high-resolution digital elevation models derived from highly accurate Light Detection and Ranging (LIDAR) remote sensing technology to predict future shorelines and distribution of habitat types for Big Pine Key based on sea level rise predictions ranging from the best-case to worst-case scenarios described in current scientific literature. In the Florida Keys, TNC models predicted that sea level rise will first result in the conversion of habitat, and eventually the complete inundation of habitat. In the best-case scenario, a rise of 7 inches (18 cm) would result in the inundation of 1,840 ac (745 ha) (34 percent) of Big Pine Key and the loss of 11 percent of the islands upland habitat (TNC 2010, p. 1). In the worst-case scenario, a rise of 4.6 feet (140 cm) would result in the inundation of about 5,950 ac (2,409 ha) (96 percent) and the loss of all upland habitat (TNC 2010, p. 1).

Similarly, using a spatially explicit model for the Keys, Ross *et al*. (2009, p. 473) found that mangrove habitats will expand steadily at the expense of upland and traditional habitats as sea level rises. Most of the upland and transitional habitat in the central portion of Sugarloaf Key is projected to be lost with a 0.2 m-rise (0.7 ft-rise) in sea level; a 0.5-m rise (1.6 ft-rise) in sea level can result in a 95 percent loss of upland habitat by 2100 (Ross *et al.* 2009, 473). Furthermore, Ross *et al*. (2009, pp. 471-478) suggested that interactions between sea-level rise and pulse disturbances (e.g., storm surges or fire [see Factor E]) can cause vegetation to change sooner than projected based on sea level alone.

The Science and Technology Committee of the Miami-Dade County Climate Change Task Force (MDCCCTF) (2008, p. 1) recognized that significant sea level rise is a very real threat to the near future for Miami-Dade County. In a January 2008 statement, the MDCCCTF (2008, pp. 2-3) warned that sea-level is expected to rise 3-5 feet (0.9-1.5 m) within this century. With a 3-4 foot (0.9-1.2 m) sea-level rise (above baseline) in Miami-Dade County: Spring high tides would be at about + 6 to 7 feet; freshwater resources would be gone; the Everglades would be inundated on the west side of Miami-Dade County; the barrier islands would be largely inundated; storm surges would be devastating; landfill sites would be exposed to erosion contaminating marine and coastal environments. Freshwater and coastal mangrove wetlands will not keep up with or offset sea level rises of two feet per century or greater. With a five foot rise (spring tides at nearly +8 feet), Miami-Dade County will be extremely diminished. (MDCCCTF 2008, pp. 2-3).

In summary, all known occurrences are at some risk to habitat loss and modification. These threats are ongoing. Extant occurrences on private land are threatened by development. The magnitude of the threat level of habitat loss from development is high; several sites are not protected. Project plans for the development of the SOCSOUTH headquarters include avoidance of the majority of the population with accompanying protection and management of approximately 60,000 individuals (Service 2011, p. 13). However, this project will need to be carefully monitored because impacts would affect the largest known occurrence of the species. Most occurrences are in low-lying areas and will be affected by rising sea level. The magnitude of the threat level of habitat loss from sea-level rise is currently low, but expected to become severe in the future.

B. Overutilization for commercial, recreational, scientific, or educational purposes:

Not known.

C. Disease or predation:

Not known. Long term ecological changes on Big Pine Key associated with fluctuations in Key deer density have been identified as one of several factors that may have had impacts on the population size of sand flax (Bradley 2006, p. 2; Bradley and Saha 2009, p. 2). However, at this time, we do not consider herbivory by Key deer to be a threat.

D. The inadequacy of existing regulatory mechanisms:

FDACS designated *Linum arenicola* (sand flax) as endangered under Chapter 5B-40, Florida Administrative

Code. This listing provides little or no habitat protection beyond the States Development of Regional Impact process, which serves to disclose impacts from projects, but provides no regulatory protection on private lands. Without local or county ordinances preventing the destruction of the plant, conservation does not occur. Most of the remaining occurrences are on private land or non-conservation public land. In summary, existing regulatory mechanisms do not protect sand flax and its habitat at most sites. This threat is imminent and the magnitude is high.

E. Other natural or manmade factors affecting its continued existence:

The lack of fires in most forest fragments in Miami-Dade County during the last century may be one reason why this species occurs primarily in disturbed areas (Bradley and Gann 1999, p. 63). Pine rocklands need regular fires to prevent hardwood encroachment and excessive accumulations of litter. Under natural conditions, lightning fires typically occurred at 3- to 7-year intervals. With fire suppression, hardwoods eventually invade pine rocklands and shade out understory species like sand flax. Fire suppression has reduced the size of the areas that burn and habitat fragmentation has prevented fire from moving across the landscape in a natural way. Thus, many pine rocklands are gradually becoming tropical hardwood hammocks. Fire suppression threatens sand flax on at least two of its remaining sites, including the largest on Big Pine Key (Table 2) (Bradley and Gann 1999, p. 63, 65; Hodges and Bradley 2006, p. 48; K. Bradley, pers. comm. 2007; Bradley and Saha 2009, p. 2).

In the fragmented pinelands of Miami-Dade County, natural fires are unlikely to occur, and if they do, will usually be suppressed. Therefore, Bradley and Gann (1999, p. 63) recommended periodic burning of all pine rocklands adjacent to occurrences of this species and suggested that a mosaic of burns should be used in management of pine rocklands. On Big Pine Key, Bradley (2006, p. 37) recommended the long-term management of this species be accomplished by ensuring that pine rockland habitat receives regular burns. Although the ideal fire regime for pine rocklands on Big Pine Key is not established, it appears that fires should occur within a range of 5-15 years, at different times of years, and at different intensities to maintain a mosaic of habitat structures (Bradley 2006, pp. 36-38).

On NKDR the Service is trying to establish a more active fire management program, but is dependent upon prescribed fire specialists stationed at other National Wildlife Refuges (A. Morkill, pers. comm. 2006). In 2003, a 120-ac (49-ha) site on NKDR was burned; this site had been unburned for 17 years. TNC actively uses prescribed fire at its 20-ac (8-ha) Terrestris Preserve. Their management goal is to maintain a growing season, short fire-return interval fire regime while limiting *Pinus elliottii* var. *densa* (slash pine) mortality, improving Key deer habitat, and maintaining or increasing abundance of four rare plant species, including sand flax (Slapcinsky and Gordon 2007, p. 1). Slapcinsky and Gordon (2007, p. 1) found the density of rare plants declined significantly in all three burn units in 2006 and attributed the response to the damaging effects of Hurricane Wilma in 2005.

In the most recent study, Bradley and Saha (2009, pp. 4-5) found that the northern areas of Big Pine Key are less dissected by roads and have burned more frequently than those in the south. The southern pinelands have been extensively fragmented by road construction, creating more edges and reducing the likelihood of fire management; these areas have burned less frequently and have denser palm / hardwood understories and deeper duff accumulations (Bradley and Saha 2009, p. 5). Bradley and Saha (2009, p. 10) found that the southern pinelands had consistently lower densities of sand flax. They believe that restoration of degraded pine rocklands of the south end of Big Pine Key will be important in increasing the total population sizes of sand flax.

Slapcinsky *et al*. (2010, pp. 4-10) examined the fire responses of 18 rare plant species from 14 families occurring on sandhill, scrub, pine rockland, and mixed deciduous hardwood communities in Florida to better understand the likely negative impacts of fire suppression. Across all species and life history traits, variables for 9 of the 18 species (50 percent) showed statistically significant positive responses to fire, and variables for 9 species (50 percent) showed neutral responses; no species showed a significantly negative response to

fire (Slapcinsky *et al*. 2010, p. 11). None of the species studied were unable to recover post-burn (Slapcinsky et al. 2010, p. 4). Sand flax showed no statistically significant trends during the period monitored (8 years) (Slapcinsky *et al*. 2010, p. 11). Slapcinsky *et al*. (2010, p. 16) suggest that the duration of monitoring might be insufficient to fully clarify patterns of responses to fire. In general, Slapcinsky *et al*. (2010, p. 4) argue that prescribed fire in pyrogenic habitats should not be delayed until species-specific responses to fire are understood. Also, the staff at NKDR is beginning to monitor the response of rare plants to prescribed fire after years of fire suppression on the Refuge (Anderson 2010, slides 16-20).

Exotic plants are a threat at half of the extant sites (Table 2) (Bradley and Gann 1999, p. 63, 65; Bradley 2006, pp. 25-27; Hodges and Bradley 2006, pp. 38-39; K. Bradley, pers. comm. 2007, Bradley 2009, pp. 1-13). As a result of human activities, at least 277 taxa of exotic plants have invaded pine rocklands throughout south Florida (Service 1999, p. 3-175). Some of these may compete directly with sand flax for space and resources, while others have a profound effect on community structure and responses to fire. *Schinus terebinthifolius* (Brazilian pepper) is the most widespread and one of the most invasive species. If left uncontrolled in a pineland where no fires are being conducted, it will form a single-species thicket that almost completely eliminates native vegetation. *Acacia auriculiformis* (Earleaf acacia), *Rhynchelytrum repens* (natal grass), *Lantana camara* (shrub verbena), and *Albizia lebbeck* (tongue tree) are some of the other exotics in pine rocklands. *Lygodium microphyllum* (Old World climbing fern) is spreading into Miami-Dade County and may become a serious problem. *Zoysia tenuifolia* (Zoysia grass) is prevalent on sand flax occurrence sites at Homestead, but control efforts are being proposed (Reaves 2010, p. 6). All of these species affect the characteristics of a fire when it does occur. Fires that once burned fairly cool with mostly pine needle duff for fuel may now burn much hotter and affect the type of community that develops following fire. Therefore, with the presence of exotic species, it is uncertain how fire, even under a managed situation, will affect sand flax.

In 2005 on Big Pine Key, Bradley (2006, p. 25) recorded 16 different exotic taxa in the study plots, with Brazilian pepper the most frequently encountered. In 2007, after the hurricanes, Bradley and Saha (2009, p. 25) recorded fewer species of exotics, but mean coverage did not change significantly. They suggested that hurricanes may favor certain species of exotics that have the ability to sprout or that take advantage of openings for seed germination (Bradley and Saha 2009, p. 25). In 2005, most plots with exotics were in the southern pinelands (i.e., 56 plots [49.1 percent]); less exotics occurred in the northern pinelands (i.e., 8 plots [1.9 percent]) (Bradley 2006, p. 25). However, northern plots were invaded by 2007 (Bradley and Saha 2009, p. 25). Bradley (2006, p. 38) recommended mechanical hardwood and exotic plant control be used along with the reintroduction of fire to provide better habitat for sand flax on Big Pine Key.

In a recent study to better understand the location and extent of invasive exotic plants and rare native plants along roadways in Miami-Dade and Monroe Counties, 88 of 121 (73 percent) total target exotic plant species were found in at least one road segment (Gorden *et al*. 2007, p. 10). Of the 16,412 road segments surveyed, 6,264 (38 percent) contained at least one exotic plant species; some segments contained more than one species of invasive exotic plant (and as many as 15) (Gordon et al. 2007, pp. 10-11). In Miami-Dade County, the most frequent naturalized invasive exotic plants recorded were Brazilian-pepper, *Tribulus cistoides* (puncture weed), and *Pennisetum purpureum* (napier grass) (Gordon *et al*. 2007, p. 11). In Monroe County, the most frequent invasive exotic plants recorded were Brazilian-pepper, Leucaena leucocephala (white leadtree) and punctureweed (Gordon *et al*. 2007, p. 11).

Given the small number of plants at most sites and the species restricted range, it is not clear that existing occurrences are large enough to persist. Persistence of sand flax on conservation lands throughout its range will likely be largely dependent upon the implementation and success of management measures, including prescribed fire and exotic plant control.

Many occurrences of sand flax are located along scraped and disturbed areas along roads, and road shoulders are a potentially important habitat (Hodges and Bradley 2006, p. 48). Sand flax occurs on road shoulders where ground cover is dominated mostly by native herbs and grasses where exotic lawn grasses have not

been planted (Bradley 2006, p. 37). Sod, such as Stenotaphrum secundatum, Paspalum notatum, Zoysia or Eremochloa, inhibits the presence of this species (Hodges and Bradley 2006, p. 41; Bradley and van der Heiden 2013, p. 10). Additionally, mechanical clearing and changes in mowing regime often needed to maintain an open canopy may impact plants (Bradley and van der Heiden 2013, pp. 7-10). Hodges and Bradley (2006, p. 41) stated that road maintenance activities are critical to the survival of this species in the lower Keys. Infrastructure projects such as underground cable and sewer and water lines may impact occurrences; herbicide spraying also impacts occurrences (Maschinski et al. 2002, Appendix B1, p. 6; Hodges and Bradley 2006, p. 41; Bradley and van der Heiden 2013, pp. 7-10). The relatively large occurrence surveyed on Lower Sugarloaf Key has been impacted by repaving of the road, which dumped asphalt on top of and adjacent to the plants (Hodges and Bradley 2006, p. 41). In addition, Bradley (2006, p. 37) indicated that much of the vegetation was heavily disturbed by dumping and removal of storm debris following Hurricane Wilma. Several piles of dumped mulch were also seen along the roadside on Lower Sugarloaf Key (owned by FDOT) in areas occupied by sand flax (Bradley 2006, p. 37). FNAI (2007, pp. 2, 23) data showed that illegal dumping is a problem at two sites on public land (Sugarloaf Key and Big Pine Key).

Given the species narrow range and the small number of individuals at many sites, sand flax is vulnerable to natural disturbances, such as hurricanes. Storm surges associated with hurricanes result in inundation of habitat with saltwater for varying durations. In 2005, the Keys were impacted by three hurricanes (Katrina, Rita, and Wilma), and vegetation in many areas was top-killed due to salt water inundation (Hodges and Bradley 2006, p. 9). Hurricane Wilma passed over Big Pine Key in October 2005, creating a storm surge in the lower Keys of up to 10 feet (3 m), flooding much of the islands pine rocklands with saltwater (Bradley 2006, p. 11; Bradley and Saha 2009, p. 2). Sand flax was not found at all in surveys 8-9 weeks after this hurricane (Bradley 2006, p. 36). Similarly, Slapcinsky and Gordon (2007, p. 7) found abundance of rare species remained stable or increased throughout monitoring at TNCs preserve until Hurricane Wilma; this hurricane caused significant reduction in frequency and density for all species, especially for sand flax density in 2006. Bradley and Saha (2009, p. 10) found sand flax in northern plots, but did not find it in any of the southern plots on Big Pine Key in their post-hurricane assessment. According to the National Oceanographic and Atmospheric Administration, Miami-Dade County, the Keys, and western Cuba are the most storm-prone areas in the Caribbean so this threat is expected to continue.

In addition, Bradley (2006, p. 36) alluded to two additional potential factors that may be causing a decline in sand flax density and abundance. Liu and Koptur (2003, p. 1186) found that aerial mosquito spraying may exacerbate the existing pollinator limitation suffered by Chamaecrista lineata var. keyensis (Big Pine partridge pea) (a candidate) by reducing the number of visits by the buzz-pollinating bees. Pesticide spraying is common on Big Pine Key and its suppression of pollinator populations may also have a long-term impact on reproduction rates of sand flax (Bradley 2006, p. 36). However, the lack of pollinator information makes assessing the affects of mosquito spraying in the Keys on sand flax difficult if not impossible (Hodges and Bradley 2006, p. 41). Liu and Koptur (2003, p. 1184) also found that Big Pine partridge pea individuals at urban edges produced fewer seeds per fruit than did individuals in a pristine forest mainly because of greater insect seed predation. Increased herbivory associated with habitat fragmentation has been found in other studies and often attributed to small-area or isolation effects (Kruess and Tscharntke 1994, 2000 and Lienert et al. 2002 as cited in Liu and Koptur 2003, p. 1184). For Big Pine partridge pea, Liu and Koptur (2003, p. 1184) suggested that increased seed predation may be due to lack of fire since habitat near the urban edge is rarely burned. Bradley (2006, p. 36) suggested that similar problems with forest fragmentation and proximity to homes and business may also be impacting sand flax. More study is needed to understand the mechanism of increased insect seed predation of sand flax associated with the urban edge.

For the most part, only small and fragmented occurrences of this plant remain. As a result, threats associated with small population size ensue. These include potential vulnerabilities from environmental (catastrophic hurricanes), demographic (potential episodes of poor reproduction), and genetic (potential inbreeding depression) threats. Viable plant populations for small, short-lived herbs may consist of tens of thousands of plants. No population viability analyses have been conducted for this species; possibly one or two

occurrences may be viable. Due to the small and fragmented nature of the current population in the Keys, stochastic events, disease or genetic bottlenecks may strongly affect this species (Hodges and Bradley 2006, p. 38).

In summary, sand flax is vulnerable to a wide array of natural and human factors, including: fire suppression, exotic plants, road maintenance and other infrastructure projects, herbicide use, mechanical clearing, changes in mowing regime, illegal dumping, pesticide spraying, hurricanes and extreme weather events, storm surges, small and isolated occurrences, and restricted range. All of these threats discussed under Factor E are imminent. The overall magnitude of these threats is high.

Conservation Measures Planned or Implemented :

In 1979, Miami-Dade County enacted the Environmentally Endangered Lands Covenant Program, which reduces taxes for private landowners of pine rocklands and tropical hardwood hammocks who agree to not develop their property and manage it for a period of 10 years (Service 1999, p. 3-177). Miami-Dade County also purchases NFCs, including tropical hammocks and pine rocklands. The Miami-Dade Forest Resources Program has regulatory authority over pine rocklands and tropical hardwood hammocks and is charged with enforcing regulations that provide partial protection on the Miami Rock Ridge (Service 1999, p. 3-177). This includes authority over all NFCs in the County, including County- and city-owned parcels (Service 1999, p. 3-177). In cooperation with the Service and IRC, Miami-Dade County funded a project to map the existing NFCs and inventory rare and sensitive plants species on these lands. This project has been completed.

In the Keys, most regulatory authority is found in the local comprehensive plan, which is enforced by the Department of Community Affairs (Service 1999, pp.3-177, 3-178). Monroe County, FDOT, and Florida Department of Community Affairs recently completed a Habitat Conservation Plan (HCP) that addresses take of the Key deer, Lower Keys marsh rabbit (*Sylvilagus palustris hefneri*), and Eastern indigo snake (*Drymarchon corais couperi*) on Big Pine and No Name Keys. Benefits to sand flax on Big Pine Key, however, may be limited mostly by the relatively small population size. On June 9, 2006, the Service issued a section 10(a)(1)(B) Incidental Take Permit (expiring June 30, 2023) consistent with the plan. The HCP allows for the loss of up to 168 ac (68 ha) of potential Key deer habitat between 2004 and 2023, including no more than 7 ac (2.8 ha) of native habitat such as pine rockland. Compensation will be provided by the acquisition of a minimum of three mitigation units for every one development unit of suitable habitat on Big Pine and No Name Keys.

FTBG considered mapping occurrences of sand flax to be a priority in 2001 and 2002 and created two site maps in 2002 (Fellows et al. 2001a, p. 3; Maschinski et al. 2002, pp. 3, 8). Monitoring was conducted at five sites in Miami-Dade County 2002 (Maschinski et al. 2002, appendix B1, p. 6). FTBG developed a Conservation Action Plan for sand flax in 2001 (Fellows et al. 2001b, pp. 1-6). FTBG continues to survey sites and provide information as resources allow (J. Possley, pers. comm. 2011).

In 2005, the Service funded IRC through the Private Stewardship Grant Program to facilitate restoration and management of privately owned pine rockland habitats in Miami-Dade County. Restoration efforts include exotic plant control, light debris removal, hardwood management, and reintroduction of pines. Management plans include recommendations for prescribed burning, debris cleanup, exotic animal control, and hydrological restoration. This project is fully completed.

In 2007, the Service funded IRC to implement conservation activities associated with three candidate plant species on pine rockland fragments in Miami-Dade County in private ownership. The objective of this project is to restore suitable habitat and reintroduce and establish new populations of the plants in pine rocklands. While this project does not specifically target sand flax, it could potentially benefit as a result of habitat restoration. In addition, the Services Coastal and Partners for Fish and Wildlife Programs are also pursuing similar habitat restoration projects, which could help improve the status of the species.

In 2008, the Service funded IRC to conduct reintroductions of one federally listed endangered plant species and four Federal candidate plant species on publicly owned pine rockland preserves in Miami-Dade County. The goal is to increase the number of occurrences of listed and candidate plant species to help implement recovery efforts and decrease risk of extinction. Target species included: sand flax, *Chamaesyce deltoidea* spp. *deltoidea* (deltoid spurge), *Brickellia mosieri* (Florida brickell-bush), *Dalea carthagenensis* var. *floridana* (Florida prairie-clover), and *Linum carteri var. carteri* (Carters small-flowered flax). Reintroductions will attempt to establish new occurrences of each species and increase population sizes. Working with a variety of partners, IRC is making progress with prescribed fire, plant cultivation, and reintroduction to select sites (Bradley and van der Heiden 2013, pp. 2-6). In April 2009, IRC began cultivation of 49 cuttings using germplasm obtained from Homestead Air Force Base (Bradley and van der Heiden 2013, pp. 3,5). In 2009, IRC successfully conducted its first prescribed fires, burning two IRC-owned sites (K. Bradley, pers. comm. 2009; Bradley 2010, p. 3). In addition to being major successes ecologically, the burns helped build experience and relationships with partner agencies (Bradley 2010, p. 3).

In October 2010, the Service funded IRC to conduct 6 to 12 additional prescribed burns on private and public lands to assist in the conservation and recovery of federally endangered plants and Federal candidate animals and plants, including sand flax (Bradley 2010, pp. 1-10). Planning is underway; prescribed fires have not yet been conducted.

The Services Coastal and Partners for Fish and Wildlife programs are also pursuing similar habitat restoration projects, which could help improve the status of the species. In 2009, $400,000 of stimulus funding was allocated for habitat restoration in Miami-Dade County through the Coastal program as part of the Pine Rockland Initiative (D. DeVore, Service, pers. comm. 2010). In addition, the Coastal program provided $100,000 for a 2-year project that will help restore pine rocklands in the Keys (D. DeVore, pers. comm. 2010). The Partners for Fish and Wildlife program is also supporting similar habitat restoration projects in Miami-Dade County and the Keys.

The FDOT collaborated on and funded a study of the approximately 650 miles (1,046 kilometers) of FDOT roadway in Miami-Dade and Monroe Counties (District 6) (Gordon *et al*. 2007, pp. 1, 3). The study was conducted by The University of Florida, in collaboration with IRC and the FNAI to survey and map exotic and rare native plants along FDOT right-of-ways within Miami-Dade and Monroe Counties and to create a database that can be updated to reflect future activities and conditions (Gordon *et al*. 2007, pp. 1, 3).

In August 2011, the Service funded IRC to conduct status surveys for sand flax, *Trichomanes punctatum* spp. *floridanum* (Florida bristle fern), and *Linum carteri* var. *carteri* (Carters small-flowered flax), at all known, current and historic locations where suitable habitat remains.

Summary of Threats :

There are 10 extant occurrences of sand flax; 14 others have been extirpated or destroyed (Tables 1, 2). Most remaining occurrences are small and isolated and located in low-lying areas. Climatic changes, including sea level rise, are long-term threats that are expected to impact the species and ultimately, substantially reduce the extent of available habitat, especially in the Keys. Clough (2008, p. 23) predicted that, even under the best of circumstances, a significant proportion of upland habitat will be lost on Big Pine Key by 2100. Sand flax is threatened by habitat loss, which is exacerbated by habitat degradation due to fire suppression, the difficulty of applying prescribed fire to pine rocklands, and threats from exotic plants (Bradley and Gann 1999, pp. 61-65; Hodges and Bradley 2006, pp. 37-41). A portion of the largest population in Miami-Dade County is currently at-risk due to a proposed development (Department of Defense 2009, p. 1); however, the majority of plants should be protected and managed (Service 2011, p. 13). Remaining habitats are fragmented. Road maintenance and illegal dumping threaten roadside populations; road maintenance activities are critical to the survival of this species in the lower Keys. Sand flax is vulnerable to natural disturbances, such as hurricanes, tropical storms, and storm surges. Reduced pollinator activity and suppression of pollinator populations from pesticides used in mosquito control may have a long-term impact on reproduction rates for this species

(Bradley 2006, p. 36). Fragmentation and proximity to homes and business may also be impacting sand flax through decreased seed production due to increased seed predation (Bradley 2006, p. 36). Mechanical clearing and infrastructure changes, changes in mowing regime, and herbicide use also threaten sand flax (Bradley and van der Heiden 2013, pp. 7-10). However, not enough information is known on sand flaxs life history or reproductive biology to assess these threats. Due to the small and fragmented nature of the population in the Keys, stochastic events, disease, or genetic bottlenecks may also strongly affect this species (Hodges and Bradley 2006, p. 38). We find that this species is warranted for listing throughout all its range, and, therefore, find that it is unnecessary to analyze whether it is threatened or endangered in a significant portion of its range.

For species that are being removed from candidate status:

_____ Is the removal based in whole or in part on one or more individual conservation efforts that you determined met the standards in the Policy for Evaluation of Conservation Efforts When Making Listing Decisions(PECE)?

Recommended Conservation Measures :

Manage plants and habitat on Big Pine Key and Village of Palmetto Bay (Bradley and Gann 1999, p. 62). Work with land managers and landowners to ensure that suitable habitat conditions persist.
Manage plants and habitat at the site adjacent to Homestead Air Reserve Base; implement pine rockland management recommendations provided by Bradley (Bradley 2009, pp. 7-9). Work with SOCSOUTH, IRC, Miami-Dade County, and the Army Corps of Engineers to retain the highest-quality habitat, greatest number of populations of Smalls milkpea and sand flax, and largest number of locations on site. Management of the higher quality habitats on the project site should consist of eliminating exotic and weedy plant species, transitioning the current mowing regime to a prescribed fire program, and augmenting the palm/shrub and tree layers (Bradley 2009, pp. 7-9).

Conduct surveys of appropriate habitat on HARB to determine if other extant populations occur on the base. Prevent further destruction or degradation of existing pine rocklands and adjacent areas (Service 1999, p. 3-191). Acquire available fragments, promote conservation easements and landowner agreements, work with private landowners, and enforce regulatory protection of pine rocklands and adjacent areas that support this species (Service 1999, p. 3-191).
Re-establish populations in natural areas and restore suitable pine rockland habitat on the Miami Rock Ridge (Bradley and Gann 1999, p. 62).
Where plants occur adjacent to (i.e., not within) pine rocklands, reintroduce the species back into pine rocklands (e.g., Camp Owaissa Bauer) (Bradley and Gann 1999, pp. 62-63).
Restore habitat in places where plants occur on scarified pine rockland (Bradley and Gann 1999, p. 63).
Maintain occurrences in disturbed areas as a source of genetic materials (Bradley and Gann 1999, p. 63).
Ensure that pine rocklands receive regular burns (Bradley 2006, pp. 37-38). Fires should probably occur within a range of about 5-15 years, and preferably occur at different times of the year and at different intensities to maintain a mosaic of habitat structures (Bradley 2006, pp. 37-38). Implement a component for monitoring that captures the health of the community and species that occur in association with sand flax (Bradley and Gann 1999, p. 63).
Control exotics in pine rockland through the careful use of manual labor, herbicides, and prescribed fire (Bradley and Gann 1999, p. 63).
Support exotics control program in the Keys and Miami-Dade County. Management of pine rocklands that contain exotics is complicated in fragmented areas bordered by urban development (Bradley and Gann 1999, p. 63); control seed sources, use outreach, and encourage the development of strategies and partnerships to maximize effectiveness.
Maintain roadside in native conditions through regular mowing without planting sod; discourage mechanical disturbance (Bradley 2006, p. 37).
Make maintenance crews aware of the existence of roadside populations and use care when working in

adjacent areas (Hodges and Bradley 2006, p. 41).
Avoid impacts from infrastructure projects such as underground cable, sewer, and water lines at existing roadside populations; work with partners to avoid and minimize impacts at extant occurrences (Hodges and Bradley 2006, p. 41).
Discourage the use of herbicide spraying of the roadside, which would impact roadside occurrences (Hodges and Bradley 2006, p. 41).
Prohibit and enforce prohibitions against illegal dumping along roads and natural areas (Bradley 2006, p. 37).
Conduct studies on reproductive biology, life history, and pollination of this species so that meaningful conservation strategies can be developed (Hodges and Bradley 2006, p. 41).
Monitor populations on an annual basis to ultimately determine trends in population size (Hodges and Bradley 2006, p. 41).
Conduct additional research to determine a better population estimate for Big Pine Key. Because of its rarity and clumped distribution, an alternate sampling method may produce more accurate results (Bradley 2006, p. 36).
Restore degraded pine rocklands on the southern portion of Big Pine Key (Bradley 2006, p. 38).
Make land managers, biologists, and others aware of its potential presence. Sand flaxs diminutive size and habitat preference make surveys difficult; however, it is possible that other populations exist (Hodges and Bradley 2006, p. 41).
Consider a plan of action to establish a Florida Keys pine rockland core conservation area and ex-situ conservation of this species (Ross et al. 2009, p. 477).

Priority Table

Magnitude	Immediacy	Taxonomy	Priority
High	Imminent	Monotypic genus	1
		Species	2
		Subspecies/Population	3
	Non-imminent	Monotypic genus	4
		Species	**5**
		Subspecies/Population	6
Moderate to Low	Imminent	Monotype genus	7
		Species	8
		Subspecies/Population	9
	Non-Imminent	Monotype genus	10
		Species	11
		Subspecies/Population	12

Rationale for Change in Listing Priority Number:

Magnitude:

There are 10 extant occurrences of sand flax; 14 others are extirpated or destroyed. Remaining Miami-Dade occurrences are located within a restricted range approximately 11.5 miles (18.5 kilometers) northeast to southwest; most are small and isolated. Viability is uncertain; it is possible that only 1-2 occurrences are large enough to be viable. Habitat loss and degradation due to development is a major threat at most sites most of the remaining occurrences are on non-conservation public land. A portion of the largest population in Miami-Dade County is at-risk due to a proposed development; however, the majority of plants at this

location will be protected and managed if the project is implemented as planned. Much of the pine rocklands on Big Pine Key are protected, and this is the location of the largest population in the Keys. Climatic changes, including sea level rise, are considered substantial threats that will permanently reduce the extent of habitat. Models by TNC for the Keys predict that sea level rise will first result in the conversion of habitat, and eventually the complete inundation of habitat. Depending upon extent of sea level rise, this may result in the inundation of 34 to 96 percent of Big Pine Key and the loss of 11 to 100 percent of upland habitat in the future. Over the long-term, these threats will be difficult to address and impossible to ameliorate. Nearly all remaining populations are threatened by fire suppression, difficulty in applying prescribed fire, road maintenance activities, exotic species, or illegal dumping. Sand flax is vulnerable to natural disturbances, such as hurricanes, tropical storms, and storm surges. Hurricane Wilma inundated most of its habitat on Big Pine Key in 2005 and plants were not found 8-9 weeks post-storm. In 2007, plants were located in the northern pinelands but not in the southern portion. Due to the small and fragmented nature of the current population, stochastic events, disease or genetic bottlenecks may strongly affect this species. No population viability analyses have been conducted; possibly two occurrences are thought to be large enough to be viable. Overall, the species faces several serious threats, including few occurrences, restricted range, uncertain viability for most occurrences, and expected substantial permanent losses of habitat due to sea level rise. Therefore, the magnitude of threats is high.

Imminence :

Habitat loss and degradation due to development or road clearing is a current threat at most of the smaller occurrence sites. A portion of the largest population in Miami-Dade County is currently at-risk due to a proposed development; however, the majority is expected to be protected and managed. This project will need to be carefully monitored to ensure these protections occur as specified. Another population in the Keys is also largely protected from development since much of it is within public and private conservation lands. Sea level rise is currently occurring and has resulted in the loss of pine rocklands. However, this is considered a long-term threat since we do not have evidence that it is currently affecting any population of sand flax. Nearly all occurrences are currently threatened by one or more of the following factors: fire suppression, difficulty in applying prescribed fire, road maintenance, exotic species, and illegal dumping. However, some efforts are underway to use prescribed fire and control exotics on conservation lands. While the initial and short-term effects of hurricanes in 2005 have been observed, the long-term effects are not known. Future hurricanes are expected. Reduced pollinator activity and suppression of pollinator populations from pesticides used in mosquito control and decreased seed production due to increased seed predation in a fragmented landscape may also affect sand flax; however, not enough information is known on this species reproductive biology or life history to assess these potential threats. Problems associated with small and isolated populations are likely occurring. Viability is uncertain for several occurrences. However, efforts are underway to improve habitat conditions and establish new populations. Overall, the species faces numerous threats, but the most consequential threats are not immediate. At this time, the largest and most viable occurrences are expected to be protected from development, but they will need to be carefully monitored. Sea level rise is expected to be a substantial long-term threat, but it is not currently impacting the species. Overall, threats are non-imminent.

__Yes__ Have you promptly reviewed all of the information received regarding the species for the purpose of determination whether emergency listing is needed?

Emergency Listing Review

__No__ Is Emergency Listing Warranted?

No, however, status should be carefully monitored. Viability of most occurrences is uncertain. The status and distribution of the species needs to be monitored closely to detect change and any further decline. The loss of

a single occurrence or even the decline of any occurrences would be detrimental to the status of the species. The Service and its partners need to implement actions to conserve this species, remove threats, and increase viability wherever possible.

Description of Monitoring:

In 2005, the Service funded a project with IRC to determine the distribution and population size of five candidate plants in the Keys, including sand flax; this project has been completed (Hodges and Bradley 2006, pp. 1-79). In 2005, the Service funded an additional project with IRC to determine the distribution and population size for three pine rockland endemic candidate plant taxa on Big Pine Key, including sand flax; this project has been completed (Bradley 2006, pp. 1-41). A follow-up study to re-inventory this and other rare plants on pine rocklands of Big Pine Key and other islands has been completed; based on this study it was estimated that the post-hurricane population size of sand flax on Big Pine Key is 2,676 plants (Bradley and Saha 2009, p. 10). A status survey was then conducted in 2013 of the remaining populations in Miami-Dade County (Bradley and van der Heiden 2013, pp. 1-34).

For the most part, however, monitoring for this species is not being actively or regularly conducted. One exception is monitoring by TNC. Active monitoring is conducted at the Terrestris Preserve (Slapcinsky and Gordon 2007, pp. 1-23). FTBG monitored five sites in Miami-Dade County in 2002 (Maschinski *et al*. 2002, appendix B1, p. 6)

In 2006, the Service completed a project with IRC and Miami-Dade County to map public and many private NFCs for the Countys geographic information system. This project provided a list of plant species for each site. The project enables Miami-Dade County to manage information on pinelands and detect changes in their extent.

Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment:

none

Indicate which State(s) did not provide any information or comment:

Florida

State Coordination:

The Service requested new information (observations, data, reports) regarding the status of this plant or any new information regarding threats to this species from: FDACS, NPS, Service (National Wildlife Refuges), Florida Department of Environmental Protection, Miami-Dade County, Florida Fish and Wildlife Commission, FNAI, IRC, Historic Bok Sanctuary, The Nature Conservancy, FTBG, Archbold Biological Station, NatureServe, University of Central Florida, Florida International University, University of Florida, Princeton, members of the Rare Plant Task Force, botanists, and others. In total, the previous assessment was sent to approximately 200 individuals. Few comments were received. All new information and comments have been incorporated.

The State of Florida does not specifically list plants in its State Wildlife Action Plan.

No new data or comments were received from the State for this assessment. Information and data previously provided have been incorporated into this assessment.

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Approval/Concurrence:

Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve:  07/15/2013
Date

Concur:  10/28/2013
Date

Did not concur: _____ _____
Date

Director's Remarks: